# BIRMINGHAM BUS LANE ENFORCEMENT SYSTEM

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## INTRODUCTION

On 8 March 1994, The MVA Consultancy (MVA) was appointed by Birmingham City Council (BCC) to provide consultancy services for the design and implementation of a trial system to deter illegal use of bus lanes. The main purpose of the system was to provide an automated system to deter drivers of unauthorised vehicles from using the bus lane. This paper describes the equipment and its installation provided by Golden River Traffic Ltd, the field trial and the evaluation of the equipment's performance.

## EQUIPMENT OVERVIEW

The Bus Lane Enforcement System depends on video camera and vision processing equipment mounted within an operational bus. The system digitally photographs vehicles in the bus lane 20m ahead of it and transmits the registration number of those vehicles to a Variable Message Sign (VMS) near the end of the bus lane. The digital images are stored and can be used for subsequent enforcement procedures (where the legal framework exists), whilst the VMS advises the driver that he/she has incorrectly used a bus lane and displays the offending vehicle's registration number.

Three subsystems form the Bus Lane Enforcement System. These are as follows: Bus Mounted System, Bus Station System and Roadside VMS. Each of these systems is further described below.

### Bus Mounted System

The Bus Mounted System records the following information relating to each vehicle that commits a bus lane offence: number plate identification with a date and time stamp, graphical image of the number plate and graphical image of the vehicle.

The Bus Mounted System consists of the following components:

**Number Plate Reader (NPR) –** This is a customised version of Computer Recognition Systems' Numberplate Reader System (NRS) using an industrial Personal Computer (PC) based image processor. A colour video camera provides a wide angle view of the offending vehicle, whilst a monochrome video camera gives a close up view of the vehicle's number plate. An infra-red illuminator enables operation in poor lighting conditions.

**Power Conditioning and Control Unit (PCCU) –** This carries out DC/DC conversion for the purposes of supplying power to the other Bus Mounted System components. It also features a 30 minute Uninterruptable Power Supply (UPS), in the event of the bus battery failing.

**Bus location equipment –** A GEC-Marconi Communications Tele-Tag Interrogator informs the NPR whether or not the bus is in the bus lane. This is achieved by locating semi-passive microwave tags which are attached to street furniture alongside the bus lane. These operate in the license exempt 2.45GHz band.

**Wireless Local Area Network (LAN) equipment –** This provides a connection between the NPR and Bus Station System, allowing automatic transfer of data at speeds of up to 3Mbps using the license exempt 2.45GHz microwave band. Frequency-hopping, spread-spectrum techniques provide robust and reliable wireless communications with interference avoidance, as well as the ability to coexist with other wireless networks.

**Radio modem equipment –** This provides a connection between the NPR and Variable Message Sign. By utilising the license exempt 418MHz UHF band, potentially expensive airtime charges are avoided.

Whilst in the bus lane, the NPR reads the number plates of all preceding vehicles. The NPR provides real time operation with automatic triggering during all lighting conditions. In order to minimise the recording of redundant information and thus speed off-line processing, a 'whitelist' of exempted vehicles (*e.g.* buses, taxis and emergency vehicles) is employed.

All number plate identifications that match those in the whitelist are discarded, along with the associated graphical images. If a number plate identification does not have a corresponding entry in the whitelist, it is recorded in a 'blacklist' of bus lane offenders, along with the associated date/time stamp and graphical images. The NPR then sends a command via a radio modem to the VMS in order to display the number



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plate identification.

When the bus arrives back at the station, the NPR automatically transmits the blacklist to the Bus Station System. It then automatically transfers a copy of the latest whitelist from the Bus Station System. Both operations are carried out using the wireless LAN.

**Bus Station System**

The Bus Station System consists of a PC running the bus station application software. The PC acts as a server, communicating with the Bus Mounted System via the wireless LAN. Attaching a colour printer to the PC allows images of offending vehicles to be printed, a sample of which is shown in Figure 2.

For each violation, the Bus Mounted System transfers a single Bus Lane Offence (BLO) file to the bus station PC. These sequentially numbered files contain the following information: text format number plate identification with a date and time stamp, Windows bitmap format graphical image of the vehicle registration plate and JPEG format graphical image of the vehicle.

The BLO file is separated into three files by the bus station application. The source file is then deleted. For each number plate identification transferred from the Bus Mounted System, the Bus Station System compares the registration against the whitelist.

Any number plate identification that matches a record in the whitelist is discarded, along with the associated graphical images. Although this check is also performed by the Bus Mounted System, the Bus Station System repeats this comparison as a double-check, particularly in case the whitelist has changed since the copy held by the Bus Mounted System. If a number plate identification does not have a corresponding entry in the whitelist, the three files are written to the blacklist database.

The Bus Station System allows the whitelist to be edited and makes it available to the Bus Mounted System for transmitting via the wireless LAN. The Bus Mounted System is responsible for all issues relating to the transfer of data to and from the Bus Station System.

The bus station application runs under Windows 95. Its main Graphical User Interface (GUI) is illustrated in Figure 3 and comprises four main areas:

**File list –** A scrollable list of all the BLO records held in the database.

**Violation display/control panel –** For displaying, copying, printing and deleting the selected BLO records.

**Main control panel –** For configuration of the printing, whitelist and automatic download facilities.

**Status bar –** Shows the time of the next automatic download, the current time, date and disc usage.

**Roadside VMS**

The VMS displays information about vehicles which are illegally using the bus lane. There are three lines of display of up to eight characters in each. The first two lines are a fixed text message saying “BUS LANE OFFENCE” and the bottom line displays the alpha numeric text from the number plate of an offending vehicle. A typical legend is shown in Figure 1 below.


**Figure 1 - Variable Message Sign**

The VMS utilises high brightness amber LED technology. Each character is 140mm in height. The variable characters are made up from a 7 x 5 dot matrix, where each dot is made up from a 2 x 2 cluster of LEDs.

Nine different brightness levels ensure that the sign can be read in all envisaged lighting conditions. The VMS automatically selects a brightness level appropriate to the current ambient light conditions.

On transmission of a number plate identification from the Bus Mounted System via the radio modem link, there is a delay of no more than 2 seconds before the VMS displays the corresponding message. The legend display time is user configurable to suit local traffic conditions.



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## INSTALLATION

The Bus Lane Enforcement System was installed during the period October to November 1996. The test site was a 350m length of southbound bus lane on the A34 Stratford Road between Farm Road and Highgate Road in Sparkbrook, Birmingham. The hours of operation of the bus lane were weekdays 16:00 to 19:00 hours.

### Bus Mounted System

An out-of-service bus was provided by West Midlands Travel (WMT) for the installation of the Bus Mounted System. This allowed repeated trips along Stratford Road during the operating period of the bus lane. There are normally 50 buses per hour travelling down this route during the peak period. Completing an average of 8 circuits per hour using a single bus simulated the situation where 16% of the buses were fitted with bus lane enforcement equipment.

The Bus Mounted System cameras were originally targetted at vehicles travelling 10m ahead of the bus. However, in practice this was found to be too short a distance to capture bus lane offenders, which resulted in the target range being doubled before the formal trial began.

Another modification to the Bus Mounted System was the addition of a constant video recording facility. This consisted of an SVHS Video Cassette Recorder (VCR) connected to the output of the monochrome camera, *i.e.* that used by the NPR to actually read the number plates. The VCR featured an alarm input which was connected to the output of the bus location equipment, so as to ensure that recording only took place whilst the bus was actually in the bus lane. The video recordings were subsequently used to determine the success rate of the NPR in reading number plates.

### Bus Station System

The Bus Station System was installed at WMT's garage at Acocks Green, which was only a few miles from the trial site, but well over 60 miles from the manufacturer's site. A modem line was therefore installed to facilitate remote interrogation of the Bus Station System (and the Bus Mounted System via the wireless LAN).

### Roadside VMS

The site of the VMS installation was at the junction between Parmerston Road and Stratford Road. The only changes made to this equipment were relating to the legend display time. This had initially been set to 10s, but following initial trial runs down the bus lane, it was extended to 40s in order that bus lane offenders whose number plates were captured at the top end of the bus lane still had their readings displayed on the VMS when they reached the bottom end of the bus lane.

## FIELD TRIAL

In order that the effectiveness of the Bus Lane Enforcement System could be assessed, various surveys were undertaken before and after its installation. These were as follows: current bus lane offence levels, queue lengths, bus journey times and junction turning movement counts.

The first phase of the trial using the 20m target range began in January 1997. However, due to the fact that Highgate Road was closed for roadworks for an extended period, it was decided to suspend the trial only a few days after it had begun. The changes in traffic flows associated with the roadworks would have made the results from an after survey incompatible with the results of the before survey (which had already been conducted).

The second phase of the trial commenced in June 1997 and was completed in July 1997.

## EVALUATION

The level of bus lane offences committed decreased by 60% between the before and after surveys. Average bus journey times decreased by 32% and, not surprisingly, reduced queuing in the bus lane was observed.

In addition to the before and after surveys, a survey of driver's attitudes was conducted. Of the 1150 postage-paid questionnaires distributed, a total of 120 were returned completed, *i.e.* 10.4%.

71% of the respondents used the Stratford Road bus lane every day and 88% were familiar with its operating rules. 73% of the respondents were already aware of the Bus Lane Enforcement system and 44% had seen it in operation.

Assume, however unlikely, that a bus lane offender is captured during every circuit. The VMS will therefore be displaying an offending vehicle's number plate for 9% of the time. This only serves to demonstrate how high the 44% figure is, relative to the expected value.

## ROADSIDE MOUNTED SYSTEM

A further field trial is currently being planned, taking the Bus Mounted System components and adapting them for roadside use. On completion of this second trial, a comparison will be made between the effectiveness of a bus mounted and roadside Bus Lane Enforcement System.

The bus location and wireless LAN equipment will be dispensed with, as the Roadside Mounted System will



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be installed permanently in the bus lane, whilst the BLO files will be transferred via a PSTN modem connection to the Bus Station PC.

## OTHER BUS LANE ENFORCEMENT SYSTEMS

The Traffic Director for London is presently employing two different bus lane enforcement systems as part of its Bus Lane Enforcement Cameras Project London Area Scheme (1). The main difference between these systems and the one employed in Birmingham is the fact that both have been Type Approved by the Home Office, *i.e.* the evidence they produce is sufficient to achieve prosecution of the offending drivers. Guidance on the requirements and procedures for obtaining Type Approval have been published by the Police Scientific Development Branch (PSDB) (2).

One of the Traffic Director's systems is roadside mounted, whilst the other is bus mounted. Both rely on SVHS VCR technology, rather than digital video images, as employed in the Birmingham system. By employing video cassettes as the only form of evidence, the system operator is forced into its costly manual collection. As long as sufficient encoding algorithms are employed, it is theoretically possible to automatically transmit digital images from the point of capture to an administrative centre, thereby saving both the time and money associated with manual collection. It should be noted that for a prosecution to be successful, a notice of intention to prosecute must be issued to the accused within 14 days of the alleged offence having taken place.

The other main difference is the use of an NPR in Birmingham to filter out redundant information via a whitelist of exempted vehicles. This is also believed to be the first use of an NPR on a moving platform. The NPR's primary function, however, is to facilitate the use of a VMS as a bus lane deterrent. What remains to be seen is which of the systems presently available best achieves this primary aim of reducing bus lane offences and thereby reducing the bus journey times.

## CONCLUSION

The Birmingham Bus Lane Enforcement System was designed to serve two purposes. The digital images could be used for subsequent enforcement procedures (when the legal framework exists), whilst the VMS advises the driver that he/she has incorrectly used a bus lane and displays the offending vehicle's registration number.

The system is unique in that it is the first time an automatic NPR has been installed in a moving vehicle. It is also the first bus lane enforcement system to employ digital video technology.

The deterrence aspect of the system was successful with a significant 60% decrease in the illegal use of the bus lane and a resulting 32% decrease in average bus journey times being achieved.

Despite only one bus being instrumented for the trial, 44% of drivers who took part in a survey had witnessed the system in operation.

In summary, the Birmingham Bus Lane Enforcement System proved to be an effective means to increase the availability of a bus lane. The system is a potential method of implementing a 'clear bus lane' policy.

## REFERENCES

1. Turner D and Monger P, 1997, "The Bus Lane Enforcement Cameras Project: The London Area Scheme", Traffic Engineering & Control, Vol. 38, 529 – 539

2. Lewis S, 1996, "The Bus Lane Enforcement Camera Handbook (Provisional)", PSDB Publication No. 17/96, Home Office, St Albans, UK



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**Figure 2 - Printed Bus Lane Offence Record**

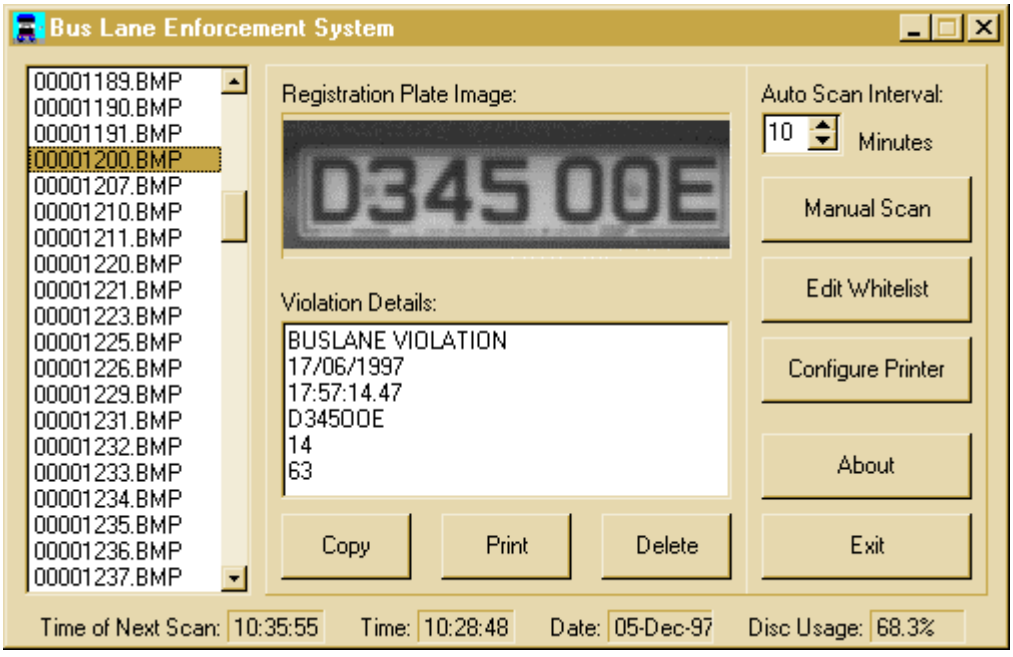


**Figure 3 - Bus Lane Application GUI**


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